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PULSE-SENSITIVE ELECTROEXPLOSIVE DEVICES

Monthly Progress Report for December 1962

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Naval Weapons Laboratory
Dahlgren, Virginia

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PULSE-SENSITIVE ELECTROEXPLOSIVE DEVICES

1. INTRODUCTION

This is the sixth monthly progress report of the program to study the behavior of electrically pulsed metal films on substrates of high thermal conductivity (Reference 1). Phase I is the feasibility and process development study.

2. OBJECT

The purpose of this program is to investigate the behavior of a metallic film when it is electrically heated and is in physical contact with a heat sink. Specifically, the aim is to study the variable parameters and to develop a manufacturing process or processes for applying a bridge heating element to a ceramic surface with the required thermal contact.

3. WORK PERFORMED DURING DECEMBER

The glass header test units have been received. The identically dimensioned beryllium oxide (BeO) header units have not been delivered, but are expected during January.

Fifty small charge holders have been made for explosive-ignition tests.

Some difficulty has been experienced with gold films which have been deposited on a number of the glass headers. Breaking down of the films occurs around the edge of the pins. Originally, it was thought to be caused by the interface region between the glass and metal pins of the headers. While this interface is very thin, the deposited film exhibits a defect at this point when pulsed electrically. In an attempt to overcome this problem, the film width between the pins was narrowed to an hourglass shape as shown in Figures 1 and 2. Units have been prepared with this shape with a dc resistance of 0.1 ohm. The same defect of burning around the pins has been frequently observed and is shown in Figure 1.

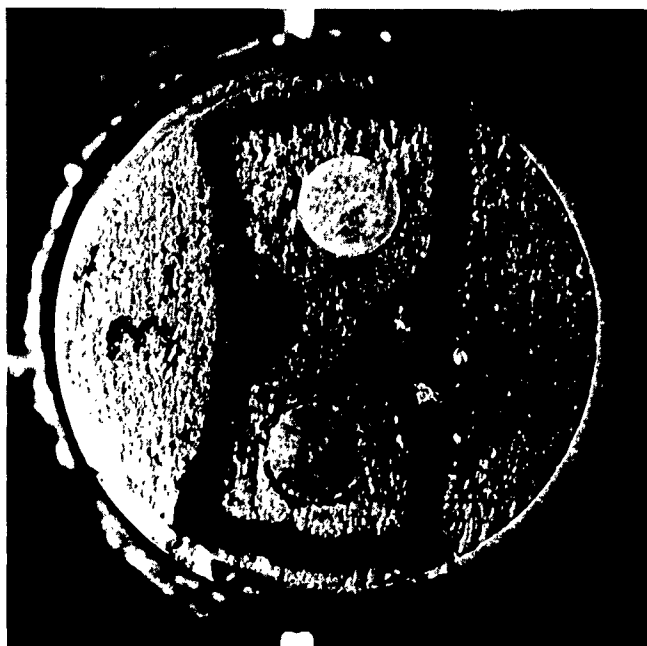


Figure 1. Narrowed Gold-Film Bridge
Showing Breakdown Around Pin.

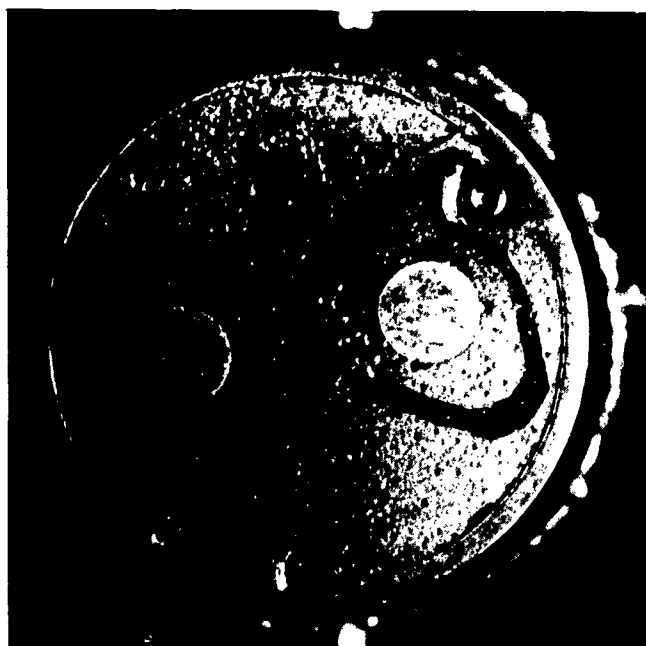


Figure 2. Narrowed Gold-Film Bridge
Showing Breakdown Between Pins.

Vacuum evaporated films generally possess tensile stresses (Reference 2). This stress is related to the degree of mobility of the atoms in the deposit at the substrate temperature or the temperature of the upper regions of the growing deposit. Heating of the substrate will, therefore, result in lower residual stresses in the deposited film. Residual stresses in aluminum films are reported to be less than in gold films, and stresses in gold films much less than for iron, nickel, or palladium.

Tests with units heated with a heating element to approximately 100°C during the film-deposition process appear to give a more desirable result of film burnout between the pins, as shown in Figure 2. Additional tests are planned to investigate this. It is possible that a film defect occurs because of the differences in thermal conductivity or crystalline form of metal pin and glass substrate, which affects the film structure when deposition takes place. If this is the problem, a different set of conditions for film deposition may be required on the BeO header units.

The pulse-heating tests with films on the glass header units frequently show a series of heated lines across the film. It has been suggested (Reference 3) that the formation of these striations perpendicular to the length of the film may be the result of thermal expansion causing the film to break away from the glass substrate. The portion of the film pulled away from the substrate then heats further and burns out. Such a phenomenon of expansion and burning cannot be readily expressed mathematically, since the areas involved cannot be predicted.

Thermal expansion resulting from the heating current might also explain the film burnout observed at the edge of the connecting pins. Increasing the thickness of the film on and near the pins might prevent expansion at the pin edge by causing the major heating to occur in the film between the pins where it is thinner, has a smaller cross-sectional area, and, therefore, a higher resistance. An investigation is being made of the available Aerojet equipment in order to conduct high-speed framing camera studies of this film bridge when pulse heated.

4. WORK PLANNED FOR NEXT PERIOD

- a. Continue film deposition investigation.
- b. Continue film heating test.
- c. Prepare explosive loading tools.
- d. Prepare for explosive testing.

REFERENCES

1. U. S. Naval Weapons Laboratory, Contract N178-8107, dated 30 June 1962.
2. Holland, L., Vacuum Deposition of Thin Films, John Wiley & Sons, Inc., New York (1961).
3. Zernow, L., Wright, F., Jr., and Woffirder, G., Exploding Wires, Volume 2, Plenum Press, Inc., New York (1962).